Surface-Modified Alginate Bioplastics: Biodegradable Sorbents for Selective Oil Spill Remediation

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Marine oil spills release toxic polycyclic aromatic hydrocarbons and other compounds that harm organisms and bioaccumulate across food chains. Meanwhile, conventional remediation primarily relies on polypropylene sorbents that contribute to microplastic pollution and involve unsustainable disposal pathways. This research develops and evaluates a sustainable alginate, handleable bioplastic alternative to polypropylene for oil sorption. Sodium alginate from brown seaweed was cross-linked with calcium chloride in a reaction and reinforced on a gauze scaffold. Cellulose nanofibers (CNF), beeswax nanoparticles (BWNP), and other surface-modification methods were used to produce and assess optimal porosity and oleophilicity. Oil absorption was assessed using 24-hour mass-percent increase trials and compared with that of polypropylene. Polypropylene showed an average mass increase of 516.65%, while the optimized bioplastic achieved 374.25%, or approximately 72% of polypropylene's. Reducing BWNP decreased absorption to 116.87%, while reducing CNF lowered it to 58.21%, indicative of the influence of nonpolar beeswax and structural reinforcement. Cross-linking durations of 2.0, 5.0, and 15.0 minutes resulted in nonlinear absorption, and slow air-drying reduced it to 193.86%, reflecting optimizable structural compositions. 30-day biodegradation testing exhibited 32.06% mass loss for bioplastics compared to 0.00% for polypropylene. Additional performance analyses included thermal decomposition, durability, and microscopy characterization. These findings demonstrate that these bioplastics offer substantial oil sorption capacity and biodegradability, projecting their promise as environmentally responsible alternatives to the forefront polypropylene sorbents for oil spill remediation.

Awards Won:
Third Award of $1,200